METHOD AND ARRANGEMENT FOR ADAPTING TO VARIATIONS IN AN AVAILABLE BANDWIDTH TO A LOCAL NETWORK

TECHNICAL FIELD

The present invention relates to communications networks in general, and specifically to adaptation to variations in available bandwidth for a local network.

BACKGROUND

Recently there has been a growing interest in the so called beyond 3rd generation (B3G) wireless systems. There seems to be a common understanding that these systems will be composed of heterogeneous technologies both on the terminal side (mobile phones, laptops, PDA's, etc.) and the network side (fixed and radio access technologies, transmission systems, etc.) [1], [2]. From the end-user's perspective, these systems promise to deliver ubiquitous connectivity [3] and a wide range of high-quality services [4], [5].

Ubiquitous service provision involves scenarios where connectivity is provided to passengers traveling on some vehicle, such as a bus, train, boat or an aircraft [3], [6]. In fact, such local moving or vehicular network scenarios have recently been identified as an important standardization area by the Internet Engineering Task Force [7].

In a moving network scenario, in which the vehicle uses a wireless (satellite, cellular or WLAN) link to be connected to a fixed access point (base station); the available bandwidth between the local network in the vehicle and some stationary access point or access router can vary as the vehicle moves between access points. In general, these access

points do not have to belong to the same radio access technology (RAT). For instance, when a train arrives at a station, it may provide connectivity through a large-capacity wireless local area network (WLAN). When leaving the station it may switch to cellular access such as a 3G or UMTS network. Also, while within the same RAT, available bandwidth may fluctuate due to mobility or changes in the radio conditions (fading, shadowing, etc). Due to the variations in the available bandwidth for the vehicular network, individual users, who share the total available bandwidth, will experience a variation in the bandwidth available for each user.

In a multi-access scenario with vehicular networks, all traffic coming from the users connected to a wireless gateway can be aggregated in a few shared bearers having high bandwidth. Each such bearer carries a specific type of traffic, i.e. data traffic of similar type from several users is multiplexed into the same aggregated or shared bearer.

When the vehicle enters a cell or a new access with different available bandwidth, an adaptation occurs, e.g. one or more shared radio channels (i.e. bearers) between the vehicular network and an available access router in another network are torn down or preferably their respective bandwidth is modified up or down to a suitable level. In a straight forward procedure, one or more users whose traffic prior to the bandwidth change is multiplexed into the shared bearer are dropped.

SUMMARY

A general problem with prior art vehicular networks is that a reduction in available bandwidth leads to arbitrary and non-predictable interruptions of user traffic. In view of this problem it is an object of

the present invention to provide a method and an arrangement for improved adaptation to variations in available bandwidth for a local network.

A further object of the invention is to enable maintaining connectivity with at least some minimum quality of service for as many connected users as possible, while at the same time adapting the bandwidth for the individual users to match the change in total available bandwidth of the local network.

Another further object of the present invention is to provide a method for identifying users to be affected by a change in available bandwidth of the shared bearers and for notifying the identified users of the change.

These objects are achieved by methods and devices in accordance with the attached claims.

Briefly, information concerning all aggregated bearers and their associated QoS values is collected, stored and updated continuously. Also, information about each connected user and their on-going sessions is collected. The user information preferably comprises QoS parameters, Internet Protocol (IP) information and information concerning utilized bearers. When a change is detected in an aggregated bearer the method according to the invention utilizes the information concerning the bearer and the users utilizing the bearer in order to identify users suitable to have their bit rate adapted. This identification is preferably performed by comparing the current bit rate for a user with a minimum or maximum bit rate for the user, and based on that comparison deciding if the user should be targeted for an adaptation of its allocated bandwidth. Consequently, the identified

users are notified about the required adaptation. Finally the adaptation of the allocated bandwidth for the identified users is performed.

In order to perform said method according to the invention an arrangement for enabling said adaptation is provided. The arrangement comprises means for detecting the change in bandwidth available for the network, means for identifying users, means for notifying users and finally means for adapting the allocated bandwidth for each identified user. Further, in order to enable the detection and the identification the arrangement preferably comprises two databases for collecting and storing information concerning the users and the bearers in the network.

The advantages with the present invention is that it enables maintaining at least a minimum QoS for as many users as possible, while at the same time adapting to a change in the bandwidth available for the local network. Additionally, due to the notifying step the affected users are made aware of a change and can choose how to adapt to the required change.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

Fig. 1 is a schematic block diagram of a vehicular network and a stationary network.

Fig. 2 is a block diagram of communicating networks.

Fig. 3 is a flow diagram of main steps of an embodiment of a method according to the invention.

Fig. 4 is a flow diagram of part of another embodiment of the method according to the invention.

Fig 5 is a flow diagram of a special case of the embodiment in Fig. 4, having users associated with a service class according to the invention.

Fig. 6 is a schematic block diagram of an embodiment of a wireless gateway according to the invention.

DETAILED DESCRIPTION

In order to fully understand the present invention a further background is provided below, where in addition to the specifics of the present invention the context of the described problem is further discussed.

The present invention is applicable to local networks in general, but will be described with reference to a vehicular wireless network since the problem with bandwidth variations is more pronounced in a vehicular scenario.

The method according to the invention will in the following enabling embodiments be described as implemented as part of the functionality of a wireless gateway in a wireless vehicular network. It is however implied that corresponding functionalities can reside in other parts of a mobile router, the wireless vehicular network or in some other part of an associated communications network.

The only assumption in the implementations of the embodiments is the availability of a Layer-2 (L2) notification message from the access router to the wireless gateway, which normally exists.

Since the present invention mostly relates to the identification and notification of user equipment to be affected and required to adapt in the vehicular network, all other functionalities are assumed to be performed according to common knowledge of anyone skilled in the art and are thus not further explained.

In Fig. 1 a schematic block diagram of a vehicular network 10 connected to some stationary network 90 (e.g. UMTS, WLAN) is illustrated. The vehicular network 10 comprises a mobile router 30 having a plurality of connected user equipment 20. Each user equipment 20 has an associated individual bearer or channel with an allocated or individual bandwidth providing connectivity to the mobile router 30. The mobile router 30 has a few large aggregated bearers providing connectivity to the stationary network 90; those bearers together provide the available bandwidth between the networks 10, 90.

The mobile router 30 is a layer-3 (L3) entity that is a fundamental component in the vehicular network scenario and is part of the vehicular network 10. The mobile router 30 is similar to a standard IP router in the sense that it provides an L3 routing and packet forwarding service to/from users or user equipment in the vehicular network 10. It is however capable of changing its point of attachment to an IP backbone and hiding IP mobility for the users in the vehicle [7]. In practice, the mobile router 30 is often extended to incorporate higher layer functionalities such as web caching, various signaling functionalities (e.g. SIP/SDP) and other proxy functionalities (e.g. TCP) [9]. These functionalities are however not part of the basic moving network scenario. Therefore, technical solutions to provide quality of service (QoS) and adaptation support should not rely on the

assumption that higher layer-5/7 (L5/7) entities are present or co-located with the mobile router.

Since the mobile router 30 has to provide L3 routing and packet forwarding service, it preferably contains support for some wireless access technology. Therefore the mobile router 30 is assumed to also provide some wireless gateway functionality that allows set up, maintenance and tearing down of wireless bearers between the mobile router 30 in the vehicle and an access router of the landline backbone network 90. However, it is implied that the wireless gateway functionality can be provided elsewhere in the vehicular network or outside the vehicular network.

Each user equipment 20, in a known manner, contains the applications (supporting voice-over-IP, a streaming client, web browser, etc.) that the user uses to access various services. This can be a laptop with a wireless interface or a personal digital assistant (PDA) equipped with a Bluetooth capability. The user equipment 20 contains an operating system (OS) and several signaling modules (not shown), including a Session Initiation/Description Protocol (SIP/SDP) [11,12] Real Time Signaling Protocol (RTSP) [13], RTCP [14] and Next Steps in Signaling (NSIS) [15] Protocol and possibly other. However, these are well known entities, and are therefore not further described.

Each user equipment 20 also can contain several layer-2 (L2) drivers and interfaces, such as Ethernet, infrared, Bluetooth, WLAN, etc. These L2 interfaces allow the user equipment to get connected to the wireless gateway functionality.

In Fig. 2 another block diagram of communicating networks 10, 90 is shown. Here the local or vehicular network 10 comprises node or a

wireless gateway 50, which can be part of the mobile router 30 but as mentioned before located elsewhere in the vehicular network or in the communication system, with a plurality of connected user equipment 20. Each user equipment 20 has an associated bearer 70 with an allocated bandwidth to the wireless gateway 50 and the wireless gateway 50 has a plurality of associated shared or aggregated bearers 60 providing the available bandwidth to an access router 100 of a stationary network 90.

It is important to note that individual users or user equipment 20 connected to the vehicular network 10 may be completely unaware of the access technology that is used to provide the wireless bearer service between the mobile router 30 and the landline access router 100 (via some wireless access point).

For instance, passengers in a vehicle may use Ethernet or WLAN technology aboard to be connected to some "on board entertainment server" (that may contain the wireless gateway) while the server may use a cellular or satellite link to connect to some access point (and further to an access router of a public/private IP network such as the Internet or an enterprise network). As seen from the IP layer, the packet delivery service between the wireless gateway and the access router that represents the first IP hop is called the wireless bearer service. This bearer service involves all the necessary control and user plane functionalities that are required to provide a reliable and QoS aware packet delivery service between the mobile router 30 and the access router. For instance, in UMTS the bearer service involves the operation of the packet data protocol (PDP) context and the user plane operations (e.g. scheduling) of the various user traffic (conversational, streaming, interactive, background and signaling) [8].

The wireless gateway 90, in a known manner utilizes a few wireless connections to the access point (and a few bearers 60 toward the access router), each with associated quality of service (QoS) characteristics. As already mentioned, passenger or user data traffic belonging to similar quality classes and requesting similar service quality can be multiplexed into *aggregated* or *shared bearers*. This solution allows the separation of, for instance, voice-over-IP users from Internet browsing users, and/or the separation of "business class" users from "tourist class" users.

As an example of a vehicular scenario experiencing the above mentioned problem, consider passengers traveling on a train, where the train hosts a mobile router. Assume that the train enters a congested UMTS Terrestrial Radio Access Network (UTRAN) cell, i.e. a cell with a reduced available bandwidth. UTRAN contains WCDMA congestion control algorithms that allows it not to tear down the radio channel but to decrease or adapt the bandwidth of the shared radio channel or bearer to a suitable value (e.g. from 2Mb/s to 128 kb/s). In that situation some users, using the shared (and now adapted) bearer, have to adapt their service to a suitable rate (down-switch) such that the sum of the bit-rates available to the individual IP flows does not exceed this reduced value (in the example 128 kbps). If the service continues at the old higher rate, the data buffer in the network (e.g. in the RCN) will go in overflow, producing loss of packets. There is also the reverse mechanism, if the wireless gateway hand-off to an unloaded cell from a bit-rate constrained cell or enters a new access with higher bandwidth, more bandwidth is reserved for the shared channel and subsequently some users can be adapted (up-switch).

A detailed description of an embodiment of the method according to the invention for adapting to said variations in available bandwidth to

the vehicular or local network 10 will be performed with reference to Fig. 3.

During start up of the vehicular network the bearers or bearer service (both in the vehicular network and to the stationary network) are set up according to known methods.

In a first step S0 according to the invention, information regarding each bearer is collected and stored in a table or a bearer data base. The information can concern various aspects of information, but at least a bearer label (e.g. A, B, C, etc.) identifying each bearer and an associated available aggregated or shared L2 quality of service (QoS). The bearer data base is then continuously updated each time a QoS value changes due to congestion or decongestion, or when the train with the vehicular network moves to a new cell within one access or changes to a new access, or alternatively when a new bearer is set up or old ones are torn down.

Also in said first step S0, during the user session set up phase, each user or user equipment exchanges information with its peer entity using IP or higher-level protocols (e.g. NSIS to reserve resources, SIP for video conference session set up or RSTP for streaming session set up). This information contains QoS parameters (e.g. bit rate, delay, etc) and IP parameters (e.g. IP destination and source address and port) characterizing the data flow.

Since the wireless gateway can intercept the above mentioned messages, each time user equipment connects to the vehicular network i.e. the mobile router or the node or wireless gateway , collects the information regarding QoS parameters, internet protocol (IP) information and utilized bearer and stores it in a table or user data

base. QoS parameters include preferably at least a current bit rate, and the IP information includes at least the IP address of each user equipment.

Preferably the collected information in the user data base includes:

- IP information (5-tuple): Protocol type, source and destination IP addresses, and source/destination ports of the user and its peer entity, for uplink and downlink directions.
- QoS information. QoS parameters such as bandwidth, delay, jitter, etc. requested for data and other information related to the user (e.g. type of contract, i.e. gold/silver/bronze)

The QoS parameters preferably also include a minimum bit rate and a maximum bit rate. The minimum bit rate is a bit rate below which the user equipment cannot receive a requested QoS.

The user data base is updated continuously and/or at least each time user equipment connects and/or disconnects from the vehicular network. Updates are also possible or preferably necessary when user equipment switches from one type of data traffic to another, thereby possibly switching to another aggregated bearer.

Moreover, as the wireless gateway knows which L2 bearer carries the user traffic, it can associate each user to the bearer label (e.g. A is the bearer for streaming, B for WWW traffic, C for real time traffic, etc.). This parameter (i.e. the 5-tuple associated with L2 bearer label) is used to perform the binding between the adapted bearer and the user to be affected.

In a next step S1 according to an embodiment of the method according to the invention the vehicular network or the mobile router or some other optional entity detects a change in available bandwidth (preferably by monitoring the bearer data base) and has to decide how to adapt the connections of the connected user equipment within the network.

In the following step S2 according to the embodiment in Fig. 3, the wireless gateway or the mobile router, based on the collected information in the bearer data base, identifies the bearer with the adapted bandwidth. From the field “Bearer” in the user data base, the wireless gateway finds out all the users using that bearer. Since one or more of the users have to be switched; the selection is performed by looking at the “QoS information” field in the user data base. A simple selection method consists of selecting the users consuming a greater bandwidth, but it is also possible to take into account more complex methods considering, for instance, the type of contract or class (i.e. gold/silver/bronze user) for each user.

Assuming that a down-switch is required, an exemplary identification method for step S2 according to the embodiment in Fig. 3 will be described with reference to Fig. 4.

Initially the first user equipment in the user data base is selected. The difference between the current bit rate and the minimum bit rate for the selected user equipment is calculated. If the difference is equal to zero the user equipment is already at its minimum bit rate, and is left unadapted. But, if the difference is larger than zero, thus indicating that the user equipment is not at its minimum bit rate, the user equipment is targeted as a candidate for a down-switch. Preferably,

the user equipment is targeted to be down-switched to its minimum bit rate, but it is likewise possible to down-switch with a smaller amount.

Subsequently the targeted down-switch is compared to the required adaptation. If it is still necessary to down-switch additional user equipment, the next user equipment in the user data base is selected and the comparison between the current and the minimum bit rate is repeated.

This process is repeated until the required adaptation is achieved, i.e. the sum (or accumulated) of the entire individual targeted down-switches or adaptations is at least equal to the change or adaptation of the available bandwidth. However, if and when all user equipment are at their respective minimum bit rate but the required adaptation is not achieved, then some user equipment have to be terminated or disconnected. This can be performed according to some random selection or some predetermined selection criteria i.e. minimum bit rate, type of traffic, type of contract etc.

When the required adaptation is achieved and a number of user equipment are targeted for down-switch, the user equipment are in step S3 with reference to Fig. 3 notified of the required down-switch. Optionally, depending on the type of traffic, also the peer entity of the user equipment can be notified of the required adaptation.

As the wireless gateway can be a NSIS, RTSP and SIP proxy, it can send directly the switch message: for instance in case of streaming the wireless gateway can send the RTSP PAUSE-PLAY messages to the streaming server, whilst in case of real time service it can send the NSIS message (containing new QoS parameters) to the user and/or to the remote side. The wireless gateway knows the IP addresses and

ports for these messages because it can find them in the "IP information " field contained in the user database.

Finally, in step S4, the individual bandwidth of each identified user equipment is adapted to their new bit rate according to the targeted down-switch.

Consequently, the user data base is again updated. A corresponding method according to the invention can be applied when more bandwidth is made available, thereby enabling user equipment to up-switch. In this case the entire change in available bandwidth does not have to be adapted to.

One additional step for the case of multiple bearers is necessary. In that case a first step in a selection method according to the invention comprises identifying all user equipment utilizing one adapted bearer, and subsequently identifying user equipment to be adapted, according to the above description.

One additional aspect of the embodiment in Fig. 4 according to the invention is illustrated in Fig. 5.

This embodiment of part of the method according to the invention is basically equal to the embodiment of a method according to the invention in Fig. 4, with the addition of using the contract or class type i.e. bronze, silver, and gold as selection criteria. In that case all user equipment with a lower contract or class has to be targeted for a down-switch before user equipment with a higher contract can be targeted. That is: all bronze have to be down-switched first, and then all silver and last all gold. This is an unfair but simple algorithm. It is

however possible to formulate a selection method that is more fair but also more complex.

By utilizing the method according to the invention, it is possible to maintain at least a minimum quality of service for the majority of user equipment in a vehicular network. Also, the method enables use equipment to adapt to variations in available bandwidth and minimize the risk of loss of data due to termination of user equipment.

Fig. 6 is a schematic block diagram of an embodiment of a wireless gateway 50 according to the invention, comprising an input/output unit, detecting means 51 adapted for detecting a change in an available bandwidth i.e. a change in an available bandwidth of a bearer 60, to the wireless gateway 50, identifying means 52 adapted for identifying user equipment 20 to be affected by the detected change, notifying means 53 adapted for notifying the identified user equipment of the required adaptation, a bearer data base 54 and a user data base 55. Also, the wireless gateway 50 comprises adapting means for performing the adaptation of the individual bandwidths for the identified user equipment 20.

In addition to the above mentioned, the wireless gateway 50 provides various L2 interfaces towards user equipment 20 and a set of interfaces towards the land-line base-stations and/or access points. The wireless gateway 50 also has the control logic to set up, modify and tear down wireless bearer services 60, such as UMTS, CDMA2000, GPRS, EDGE and possibly others.

Also, the wireless gateway 50 can comprise a translation function entity that manages user flows and maps these onto appropriate wireless bearers 60. For instance, based on L3/5 protocol and QoS

information, it maps, for instance, streaming user traffic into wireless streaming bearers, or voice (over IP) traffic into conversational bearers. For the special case, where there is a one-to-one correspondence between the user IP flows and the UMTS bearers, the details of such a mapping function are described in [6].

The bearer data base 54 comprises information regarding each of the aggregated bearers 60, such as a bearer label and an available aggregated L2 QoS value. This bearer data base 54 is updated whenever there is a change in the available bandwidth i.e. changes in the QoS value, due to congestion or decongestion or new access entering, for a bearer 60.

The user data base 55 comprise QoS information, IP information and utilized bearer for each of the user equipment 20 that is connected to the vehicular network 10.

The merit of the invention is that it requires no changes to high level protocols RTSP, NSIS, etc) or to L2 protocols in the user equipment, access router or in the access networks.

Moreover, the usage of high-level protocols to transport the switch information makes this invention independent of the underlying access technology and so it can be applied in general cases when different kinds of wireless accesses are used.

It will be understood by those skilled in the art that various modifications and changes may be made to the present invention without departure from the scope thereof, which is defined by the appended claims.

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